It is a pleasure to record my appreciation of the help received from Professor C. H. Stuart-Harris in all phases of this study, for his constructive criticism of this paper, and for the permission given to investigate patients under his care. I should like to thank the chief technician, Mr. J. Skelton, and the technical staffs of the Virus Research Laboratory, Lodge Moor Hospital, and of the department of medicine, the Royal Hospital, Sheffield, for their considerable part in this study; in particular, Miss Lynda Bebbington for her excellent assistance at all times.

REFERENCES

Carilli, A. D., Gohd, R. S., and Gordon, W. (1964). *New Engl. J. Med.*, 270, 123.
Chanock, R. M., Mufson, M. A., and Johnson, K. M. (1965). *Progr. med. Virol.*, 7, 208.
Eadie, M. B., Stott, E. J., and Grist, N. R. (1966). *Brit. med. J.*, 2, 671.
Grist, N. R., Ross, C. A. C., Bell, E. J., and Stott, E. J. (1966). *Diagnostic Methods in Clinical Virology*. Oxford.
Howard, P. (1967). *Brit. med. J.*, 3, 392.
Medical Research Council (1965). *Brit. med. J.*, 1, 775.
Moffat, M. A. J., and Sutherland, J. A. W. (1967). *Brit. med. J.*, 1, 601.
Murdoch, J. McC., Leckie, W. J. H., Downie, J., Swain, R. H. A., and Gould, J. C. (1959). *Brit. med. J.*, 2, 1277.
Ross, C. A. C., McMichael, S., Eadie, M. B., Lees, A. W., Murray, E. A., and Pinkerton, I. (1966). *Thorax*, 21, 461.
Sommerville, R. G. (1963). *Lancet*, 2, 1247.
Stark, J. E., Heath, R. B., and Curwen, M. P. (1965). *Thorax*, 20, 124.
Stenhouse, A. C. (1967). *Brit. med. J.*, 3, 461.
Stuart-Harris, C. H., Pownall, M., Scothorne, C. M., and Franks, Z. (1953). *Quart. J. Med.*, 22, 121.
Tyrrell, D. A. J. (1952). *Quart. J. Med.*, 21, 291.
Tyrrell, D. A. J. (1965). *Common Colds and Related Diseases*. London.
Walker, W. C., Douglas, A. C., Leckie, W. J. H., Pines, A., and Grant, I. W. B. (1958). *Lancet*, 1, 449.

Medical Memoranda

Paraquat Poisoning Treated by Forced Diuresis

Brit. med. J., 1968, 3, 290–291

Eight cases of poisoning (six fatal) by the weed-killer paraquat (1,1′dimethyl-4,4′-dipyridilium) have now been reported (Bullivant, 1966; Clark, McElligott, and Hurst, 1966; Almog and Tal, 1967; *Brit. med. J.*, 1967; Mourin, 1967; Campbell, 1968; Oreopoulos, Soyannwo, Sinniah, Fenton, McGeown, and Bruce, 1968). The following is a report on one such case treated by forced diuresis in which the patient recovered.

CASE REPORT

The patient, a man aged 32, was admitted to hospital on 25 November 1967 after ingestion of about 45 g. of Weedol (which contains 5% paraquat) in an attempt to poison himself. The Weedol had been partially dissolved in water. He was first seen one and a half hours after ingestion with a complaint of fiery periumbilical pain which had begun about 15 minutes after swallowing the weed-killer. He had not vomited.

He had previously been physically healthy. Since March 1967 he had noticed a change in mood with subsequent intermittent episodes of depression, loss of interest, insomnia, and paranoid feelings. He began to contemplate suicide in the latter three months when the depression deepened.

Examination on admission showed epigastric tenderness and guarding. The liver edge was just palpable below the costal margin. There was no evidence of pre-existing cardiac, pulmonary, or renal disease. Shortly after admission gastric lavage was performed and no solid Weedol particles were visible in the aspirate. Forced diuresis was begun.

Next day he complained of anterior chest tightness, frontal headache, and photophobia. Chest auscultation revealed generalized bilateral sibilant rhonchi. The abdominal pain disappeared by the eighth day and tenderness by the tenth day. The liver edge remained palpable throughout. He remained free of oral and pharyngeal ulceration. Clinical examination of the chest showed disappearance of rhonchi by the tenth day and there was no evidence of pulmonary hypertension at any time. The temperature rose on only one occasion to 99° F. (37.2° C.). A five-day course of intramuscular penicillin was started on admission and was followed by a five-day course of prednisolone, begun on the fifth day.

Investigations.—Daily chest *x*-ray films and electrocardiograms performed from time of admission showed no abnormality. The haemoglobin and absolute values were found to be normal. The white cell count was 6,650/cu. mm. on admission and 13,500/cu. mm. on the twelfth day. The E.S.R., blood urea, urine urea, serum electrolytes, serum bicarbonate, standard liver function tests, and arterial blood gas values were all persistently normal. Occult blood was not found in the stools. Creatinine clearance just before discharge was 58 ml./min.

Forced diuresis was performed by the method of Linton, Luke, Speirs, and Kennedy (1964) and continued for 24 hours. Throughout the forced diuresis two-hourly aliquots of urine were collected and blood samples were obtained at intervals. The concentrations of paraquat in each of these specimens and in one specimen of gastric aspirate were determined by the method of Daniel and Gage (1966). The lower limit of sensitivity by this method is 10 μg. of paraquat. This quantitative method is efficient but time-consuming. The urine cell counts were performed by the method of McGeachie and Kennedy (1963).

TABLE I.—*Paraquat Excretion and Serum Concentrations*

Time in Hours	Volume of Urine (ml.)	Paraquat Conc. in Urine (μg./100 ml.)	Total Paraquat in Urine (μg.)	Paraquat Conc. in Serum (μg./100 ml.)
Pre-forced diuresis ..	75	14,800	11,100	
0–2	1,775	840	14,910	85 (0 hours)
2–4	575	510	2,932	40 (4 hours)
4–6	750	490	3,675	—
6–8	950	330	3,135	—
8–10	900	230	2,070	40 (10 hours)
10–12	950	230	2,185	—
12–14	500	230	1,150	—
14–16	1,100	105	1,155	Nil (15 hours)
16–18	700	95	665	Nil (17 hours)
18–20	850	95	808	Nil (19 hours)
20–22	1,400	95	1,330	Nil (21 hours)
22–24	650	95	618	—
Total ..			46·0 mg.	

Table I shows the values of paraquat excretion and serum concentrations. Table II compares paraquat clearance with urine flow rate. It is apparent from this that the trend is for higher clearance of paraquat with the higher urine flow rate. The urine cell count figures are shown in Table III. Cell excretion reached a peak about the fourth day and thereafter fell to normal levels.

TABLE II.—*Urinary Clearance of Paraquat/Urine Flow Rate*

Time in Hours	Urine Clearance (ml./min.)	Urine Flow Rate (ml./min.)
0–2	146·2	14·8
2–4	61·2	4·8
4–6	77·5	6·3
6–8	65·2	7·9
8–10	43·1	7·5
10–12	45·4	7·9

TABLE III.—*Urine Cell Count. Normal White Cell Count—10 Cells*

Day	Red Blood Cells	White Blood Cells	Epithelial Cells	Casts
2	58	22	2	Nil
3	78	42	Nil	Nil
4	>200	>200	Nil	2
6	11	14	Nil	Nil
9	8	2	Nil	Nil
15	5	9	Nil	Nil

DISCUSSION

Weedol is a domestic weed-killer stated by the makers to contain paraquat dichloride 5%, magnesium sulphate 67%, and "surface active agents" 28%. Gramoxone W is an agricultural weed-killer in solution containing 20% of the paraquat ion. Seven cases of poisoning by a paraquat solution have been reported (Bullivant, 1966; Clark *et al.*, 1966; Almog and Tal, 1967; Mourin, 1967; Campbell, 1968; Oreopoulos *et al.*, 1968), and six of the patients have died. There were common features at necropsy. All cases showed gross proliferation of the lining epithelium of the terminal bronchioles and alveoli with associated haemorrhage and oedema. The poison was ingested in five of the fatal cases, causing gastric congestion and submucous ulceration in three. Four cases had liver damage varying from cellular swelling with fatty change to midzonal degeneration and necrosis. Three had renal tubular degeneration and another a mild myocarditis.

Unpublished details of six cases of poisoning by Weedol were supplied by I.C.I. Industrial Hygiene Research Laboratories, Cheshire. Of these only one patient died, but she had taken in addition an unknown quantity of barbiturate. One other suffered ulcerative pharyngitis. The remainder had no ill effects. The quantities ingested were indefinite but of the order of 20–200 g. of Weedol. One other case of survival after ingestion of 60 g. of Weedol is recorded (*Brit. med. J.*, 1967).

It is clear that Weedol, though containing paraquat, is not such a deadly poison as Gramoxone W. Treatment by forced diuresis has been suggested (*Brit. med. J.*, 1967), though no case treated in this manner has been reported to our knowledge. Oreopoulos *et al.* (1968) report a fatal case of paraquat poisoning in which peritoneal dialysis was carried out because of renal failure. No paraquat was detectable in blood, urine, or tissues at necropsy eight days after ingestion of paraquat. Improvement was noted in one case treated with prednisolone (Bullivant, 1966). Forced diuresis, prednisolone, and prophylactic penicillin were used in the present case.

The findings suggest that urinary excretion of paraquat is increased by forced diuresis. Serum levels were very low and the amounts removed in the urine were large in relation, though the total amount excreted in the urine (46 mg.) is small compared with the estimated amount ingested. This can be explained as follows. Daniel and Gage (1966) have shown in rats that 80% of an oral dose of paraquat in aqueous solution was excreted in the faeces. The paraquat contained in Weedol is almost certainly even less well absorbed because of its solid form and the purgative effects of magnesium sulphate. Paraquat seems to have the property of tissue-fixing, which is shown in the present case by the fact that paraquat was detectable in the urine many hours after it was last detectable in the serum. In the case reported by Campbell (1968) paraquat was detected in liver and kidney at necropsy seven days after absorption. This would seem to be a factor in its toxicity.

The only possible evidence of tissue damage in this case was (*a*) the increased urinary cell excretion—this was a transient feature and could also be accounted for by the use of catheter drainage during the forced diuresis; and (*b*) the low creatinine clearance demonstrated 11 days after ingestion.

The patient left hospital 14 days after ingestion of the poison apparently physically well. It had been intended to follow him closely as an outpatient, particularly to reassess kidney, liver, and lung function. This, however, has proved impossible despite repeated attempts to acquire the co-operation of the patient.

ADDENDUM.—*Rapid Detection of Paraquat and Diquat in Gastric Aspirate/Lavage and Urine.*—The published quantitative methods for detecting these substances are efficient but too time-consuming. A rapid qualitative side-room test, which is based on the above methods and can be effected within one minute, has been devised by one of us (S. L. T.). As yet unpublished, the procedure is: to 5 ml. of fluid add a knife-point (0.1 g.) of sodium hydrogen carbonate followed by a knife-point (0.1 g.) of sodium dithionite (hydrosulphite). Mix. Paraquat gives a blue colour and diquat gives a yellowish-green colour—20 to 50 μg./ml. can be detected without difficulty. Urine may require dilution before application of the test. Gastric aspirate/lavage may require filtration and dilution before application of the test.

We wish to thank Dr. J. D. Olav Kerr, consultant physician, for permission to publish this case report and for his helpful advice in its preparation. We are grateful to Dr. A. L. Linton, consultant physician in renal diseases, for expert guidance.

Requests for reprints should be sent to Dr. A. R. Patel, Western Infirmary, Glasgow W.1.

F. KERR, M.B., CH.B., D.OBST.R.C.O.G.,
Senior House Officer in Medicine, Western Infirmary, Glasgow.

A. R. PATEL, M.B., CH.B.,
Registrar in Medicine, Western Infirmary, Glasgow.

P. D. R. SCOTT, M.B., CH.B.,
Junior House Officer, Western Infirmary, Glasgow.

S. L. TOMPSETT, D.SC., PH.D., F.R.I.C.,
Reader in Clinical Chemistry, University of Edinburgh.

REFERENCES

Almog, Ch., and Tal, E. (1967). *Brit. med. J.*, 3, 721.
Brit. med. J., 1967, 3, 690.
Bullivant, C. M. (1966). *Brit. med. J.*, 1, 1272.
Campbell, S. (1968). *Lancet*, 1, 144.
Clark, D. G., McElligott, T. F., and Hurst, E. W. (1966). *Brit. J. industr. Med.*, 23, 126.
Daniel, J. W., and Gage, J. C. (1966). *Brit. J. industr. Med.*, 23, 133.
Linton, A. L., Luke, R. G., Speirs, I., and Kennedy, A. C. (1964). *Lancet*, 1, 1008.
McGeachie, J., and Kennedy, A. C. (1963). *J. clin. Path.*, 16, 32.
Mourin, K. A. (1967). *Brit. med. J.*, 4, 486.
Oreopoulos, D. G., Soyannwo, M. A. O., Sinniah, R., Fenton, S. S. A., McGeown, M. G., and Bruce, J. H. (1968). *Brit. med. J.*, 1, 749.